

APPLYING THE ISO 31000 RISK ASSESSMENT FRAMEWORK TO COASTAL ZONE MANAGEMENT

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Abstract

The NSW Government's *Sea Level Rise Policy Statement, Coastal Planning Guideline: Adapting to Sea Level Rise* and *Draft Guidelines for Preparing Coastal Zone Management Plans* have endorsed the use of a 'risk assessment approach' to coastal zone management. The risk assessment framework is used extensively in industry and government as it provides a process for determining sensible management outcomes even when there is considerable uncertainty or lack of data. Thus, the approach is ideal for managing the issues surrounding climate change adaptation and coastal hazards.

This paper outlines a methodology for applying the Australian Standard for Risk Management (AS/NZS ISO 31000:2009) to coastal zone management as prescribed within the various NSW Government guidelines. Steps within the risk management framework, such as 'identifying the risks', 'analysing risk likelihood and consequence', 'prioritising the risks', and 'risk treatment', can be applied to various phases of the coastal zone management process. Coastal hazards may be defined in terms of a 'likelihood' of hazard extent. At the management phase the extent and type of coastline development, recreational demand, ecological and other coastal values can be used to determine the 'consequences' of coastal hazards. Combining likelihood and consequence to define an overall level of risk provides the foundation for prioritising management efforts and resources towards the highest priority coastal risks.

There remains considerable uncertainty with respect to climate change, particularly surrounding the timeframe, extent and types of impacts that may occur. The risk assessment framework can help to accommodate uncertainty, as outcomes may be assessed and compared even when there is little available data. Given the uncertainty in timeframes for climate change impacts, our methodology advocates developing management responses that are trigger-based, rather than time-based. Using the adaptation tool developed by Fisk and Kay (2010), this paper explores the application of risk-based coastal zone planning using examples from NSW.

Background

Uncertainties associated with future climate change presents huge challenges to local government and the general public. Decisions made today are likely to have ramifications well into the future (depending on the type of infrastructure or development and its design life), so consideration of extended timeframes is essential, even though climate-related risks may not manifest as impacts for several decades.

Irrespective of climate change, coastal hazards have always presented a challenge to planners and managers. There is generally limited data on coastal processes (e.g. historical shoreline change, wave climate, water levels, etc.) and there are many different ways to assess the extent of hazards, which add to the uncertainty in estimating coastal hazards.

The risk assessment framework is a robust methodology for dealing with outcomes that are uncertain, limited data to assess outcomes, or for impacts with uncertain timeframes. The use of a risk-based approach to manage coastal hazards accords with current international best practice for natural resource management. This was recognised by the endorsement of the risk approach by the NSW Government in recent guideline documents, particularly the Draft *Guidelines for preparing Coastal Zone Management Plans* (the CZMP Guidelines) released in August 2010.

The CZMP Guidelines supersede the former Coastline Management Manual (NSW Government, 1990) and Estuary Management Manual (NSW Government, 1992) and recent *Coastal Risk Management Guide: Incorporating sea level rise benchmarks in coastal risk assessments* (2010). The key change within the CZMP Guidelines is that the adoption of 'an adaptive risk-based management approach' is prescribed as a principle for coastal management. Councils and the NSW Government are said to have acted in 'good faith' where coastal zone management plans have been prepared substantially in accordance with such coastal management principles.

The risk approach guides coastal planners (e.g. councils) to consider, analyse and prepare for impacts that may be greater than expected, or manifest earlier than expected. This includes setting trigger levels to implement strategies, developing short and long term contingencies, and using a suite of strategies that either reduce the likelihood and / or the consequence from coastal risks.

This paper demonstrates a methodology for applying the *AS/NZS ISO 31000:2009 Risk Management Principles and Guidelines* to coastal zone management. The various aspects of a standard risk management process and their application to the development of a coastal zone management plan are given below.

The Risk Assessment Process

Risk is defined as the 'effect of uncertainty on objectives' (AS/NZS ISO 31000:2009). The objectives can be financial, health and safety, environmental and so on. The risk management process involves the following steps, as given in ISO 31000:2009:

- setting objectives and establishing the context of the risk assessment;
- identifying the risks;
- analysing the risks to determine the level of risk, which is defined as the combination of the consequences and likelihood of the risk;
- evaluating the risk, to decide if a risk is acceptable, tolerable or intolerable / unacceptable;
- treating the risks, focusing on those risks which are intolerable; and
- monitoring and review, to continuously refine and improve the assessment and risk treatments.

Each of these steps can be easily adapted to the coastal zone management process. The steps involved in a risk assessment (adapted from the Australian Standard for Risk Management ISO 31000:2009) and their relationship to the coastal zone management process are presented in Figure 1, with discussion herein.

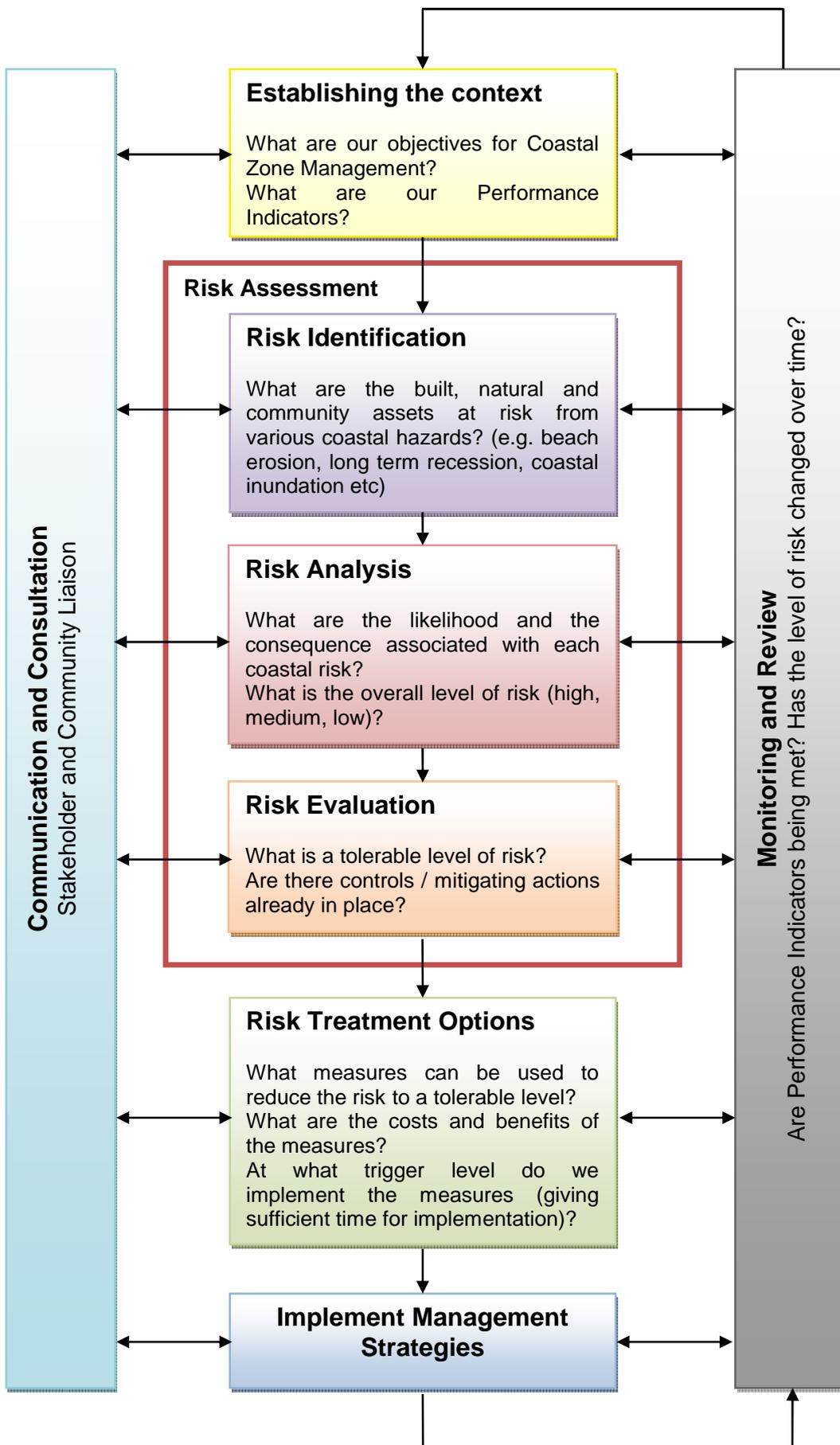


Figure 1 ISO 31000:2009 Risk Assessment Framework Adapted to Coastal Management

Establishing the Context and Setting Objectives

The *Coastal Protection Act 1979*, the CZMP Guidelines and other associated guideline documents set the context for coastal management, including intended outcomes for coastal zone management plans.

The draft CZMP Guidelines state that coastal zone management plans shall focus upon minimising the risks from coastal hazards to public and private assets. This is in recognition of the fact that coastal hazards are not explicitly managed through any other statutory process. For example, issues associated with recreational amenity and access shall only be assessed in terms of the impact upon or impact from coastal hazards. This is because recreational amenity and access, while important, are already managed through other council and state agency operational or statutory plans. Minimising the risks arising from natural coastal processes is therefore the key aspect of the context and objective of the risk assessment and subsequent coastal management actions.

The objectives for coastal zone management can also be drawn from the NSW Coastal Policy 1997, in particular, the aim of Ecologically Sustainable Development and accommodating natural coastal processes in the coastal zone. The objectives for coastal zone management shall then be tailored to the specific local conditions, in consultation with council, stakeholders and community. Performance indicators that can be used to measure the consistency with or achievement of objectives should also be determined at this stage.

Establishing the context of the risk assessment involves describing the location and extent of the study area and the coastal processes operating in this area that may generate risks. The CZMP Guidelines separate the coastline into its broad geomorphologic sub-groups, being either sandy beach systems, bluffs and cliffs comprising rock and other consolidated material, or the entrance area of estuaries/watercourses at the coast. It is important to set the context for which (part or all) of the geomorphologic sub-groups the risk assessment and coastal management plan shall address. The description of study location, scope of the study and coastal processes accords with the coastal processes and hazards definition phase of the traditional coastal planning process.

The risk assessment aims to explore (1) the potential impact (i.e. damage) on (2) a particular value (e.g. house) from (3) a threatening process (e.g. waves, sea level rise). Thus, as part of establishing the context, the economic, social and environmental values of the land where the plan applies should also be described.

Defining risk criteria is another key aspect of establishing the context for the risk assessment. This includes preparing likelihood and consequence scales and their combination into a risk matrix to determine the level of risk. Another important aspect of risk criteria is defining the level at which risk is deemed acceptable, tolerable and intolerable, with intolerable risks requiring treatment as a priority. Guidance as to the acceptability of risks is provided within the draft CZMP Guidelines. The level of risk that is deemed acceptable, tolerable and intolerable should be modified for local conditions in consultation with council and other stakeholders.

Identify the Risks

Once the context for the risk assessment and objectives for coastal management are set, identification of risk becomes more straightforward. Given that the key aim of coastal management shall be to minimise impacts that arise from coastal processes, these coastal processes are the principal source of risk. Coastal hazards derived from coastal processes are well defined in NSW, and are described in the former Coastline Management Manual (CMM, NSW Government 1990) and the more recent CZMP Guidelines.

Eight coastal hazards were defined in the CMM (1990). In the CZMP Guidelines, the list of hazards remains essentially the same, with focus on the hazards of:

- beach erosion,
- shoreline recession (including due to sea level rise),
- coastal (oceanic) inundation,
- coastal entrance or watercourse instability and
- coastal cliff or slope instability.

Where significant site specific issues exist, sand drift may also be assessed.

Analyse the Risks

The analysis of risks involves considering the likelihood and consequence of the identified risks, to determine the overall level of risk (extreme, high, medium, low). Any risk assessment to manage coastal hazards will be incomplete without describing the likelihood as well as the consequence of coastal hazards. The likelihood is both spatially and temporally dependent. For example, likelihood increases with distance towards the shoreline and with time (assuming increasing sea levels in the future). The consequence of the risks will largely relate to the extent of existing or potential future development and the values attributed to land within the coastal zone (e.g. aesthetic, recreational, ecological, etc.).

The risk assessment process inherently requires that uncertainty is transparently described, but also, provides for a scale of likelihood or consequence to be ascribed to what may possibly occur. That is, as part of the risk assessment, hazard impact greater than expected may be described, but also qualified by the likelihood of such an impact occurring.

Likelihood

There are inherent uncertainties in climate change science and also in the assumptions used to assess coastal processes and hazards. Setting hazard lines without describing their likelihood is of little value when describing the uncertainty associated with estimating the hazard extent or climate change.

Hazard definition can only be a best estimate, because it is based upon limited beach change data, variable and limited climate data, assumptions used in model packages and other limitations in assessment methodology. Climate change adds additional uncertainty to the assessment of risk from coastal processes, such as described by Cowell et al. (2006):

“uncertainty about climate change itself; uncertainty about its effect on sea levels and wave climates; and process uncertainty in modelling beach responses on timescales relevant to climate change (decades or longer)”.

Without being transparent about the assumptions used in models and assessment of coastal hazards, a ‘false sense of confidence’ has been ascribed to the hazard assessment (Cowell et al., 2006), as has occurred in NSW in the past.

Ascribing likelihood to the hazard estimates provides transparency regarding the uncertainties, limitations and assumptions used to assess hazards. In addition, ascribing likelihood to coastal hazards can educate coastal planners and the wider community that hazard lines are estimates only and not precise predictions of future shoreline response.

Indeed, a series of hazard lines providing more than one probability or likelihood could be defined, and provides better guidance for coastal managers regarding the imminence of coastal risk for which planning is required. For example at Coffs Harbour, three hazard ‘likelihoods’ were determined, being ‘almost certain’, ‘unlikely’ and ‘rare’, as given in Figure 2. The terminology is consistent with guidance given in the Companion to the Australian Standard (Standards Australia, 2004), and these terms as defined for the Coffs Harbour example are given in Table 1.

Table 2 provides the inputs to definition of these hazard likelihood zones for the beach erosion and recession hazards over the immediate, 2050 and 2100 timeframe at Coffs Harbour.

The ‘unlikely’ zone incorporates conservative estimates of coastal hazard impact. The ‘rare’ zone provides for hazard impacts greater than predicted, such as due to extreme climate conditions or climate change aspects that may theoretically occur but for which there is no recorded data. The ‘rare’ hazard zone conveys to coastal planners and the wider community the potential (and the likelihood of that potential, i.e. rare) of hazard impacts greater than predicted, enabling more advanced planning options. The ‘rare’ hazard may be regarded in a similar fashion to the Probable Maximum Flood (PMF) zone used in floodplain management.

The ‘almost certain’ line defines an area under imminent threat. For future hazards at 2050 and 2100, the ‘almost certain’ line can be a representation of the risk from coastal processes without the inclusion of sea level rise, such as adopted at Coffs Harbour, reflecting the uncertainty associated with sea level rise projections. This is consistent with recent NSW government guidelines regarding the setting of hazard zones with and without sea level rise, and conveys to the community and planners the coastal area that will almost certainly experience impact.

Methods for assessing hazards will continue to improve. Indeed, as modelling techniques and approaches improve into the future, it is anticipated that mathematical probabilities may be ascribed to hazard extents. However, at the present time the risk assessment process requires transparency about the data and methods used to identify risks, to ensure planners and managers are informed to make appropriate decisions, and this can be done through a qualitative approach.

Table 1 Risk Likelihood / Probability, Coffs Harbour

Probability	
Almost Certain	There is a high possibility the event will occur as there is a history of periodic occurrence
Likely	It is likely the event will occur as there is a history of casual occurrence
Possible	There is an approximate 50/50 chance that the event will occur
Unlikely	There is a low possibility that the event will occur, however, there is a history of infrequent and isolated occurrence
Rare	It is highly unlikely that the event will occur, except in extreme circumstances, which have not been recorded historically.

Table 2 Beach Erosion and Shoreline Recession Hazard Probability Zones, Coffs Harbour

Probability	Immediate	2050	2100
Almost Certain	'average' beach erosion ¹	Immediate 'average' beach erosion + Harbour Impact	Immediate 'average' beach erosion + Harbour Impact
Likely	NM ²	NM	NM
Possible	NM	NM	NM
Unlikely	'maximum' beach erosion at any position along the beach ¹	Immediate 'maximum' beach erosion + Harbour Impact + 0.4 m SLR	Immediate 'maximum' beach erosion + Harbour Impact + 0.9 m SLR
Rare	'extreme' beach erosion ³	<p>Worst Case of either:</p> <p>Immediate 'maximum' beach erosion + Harbour Impacts + 0.7 m SLR</p> <p>OR</p> <p>Immediate 'extreme' beach erosion + Harbour Impacts + 0.4 m SLR</p> <p>OR</p> <p>Immediate 'maximum' beach erosion + Harbour Impacts + 0.4 m SLR + more easterly wave climate</p>	<p>Worst Case of either:</p> <p>Immediate 'maximum' beach erosion + Harbour Impacts + 1.4 m SLR</p> <p>OR</p> <p>Immediate 'extreme' beach erosion + Harbour Impacts + 0.9 m SLR</p> <p>OR</p> <p>Immediate 'maximum' beach erosion + Harbour Impacts + 0.9 m SLR + more easterly wave climate</p>

¹ Measured over the past 3 - 5 decades

² NM = Not Mapped

³ Assumed to be 'maximum' erosion plus difference between 'maximum' and 'average' beach erosion

Consequence

The consequence of coastal risks such as erosion on the built, social and natural environment depends largely on the values of the land affected by the coastal risk. This includes the type of development and assets and their value to the community, for example, public assets such as surf clubs or stormwater infrastructure, the beach amenity for community or private residences. As stated by the NSW Government in various guidelines (DECCW, 2010; DP 2010), public expenditure will be prioritised towards public infrastructure and public safety before private property. This can be conveyed through the consequence scale used to assess the level of risk. An example consequence scale based upon land use and community assets is given in Table 3.

Once the consequence scale is set, investigation of land values described by GIS spatial data and community input can be used to accurately map and differentiate areas of different consequence in the coastal zone. Land use data can provide the starting point for consequence mapping. This can then be augmented with vegetation mapping and other records to map areas of high conservation value, and with community consultation to specify areas of high recreational / social value. GIS mapping can also delineate the consequence of erosion to beach areas that are limited by back beach development, or to significant ecology that is not protected within national parks or limited in geographic extent.

An example consequence map from Coffs Harbour is shown in Figure 3, with the consequence of erosion of critical infrastructure such as major arterial roads, airport or railway land considered catastrophic while erosion of open space may have relatively minor consequence.

Table 3 Risk Consequence Scale

Consequence	Community Assets Infrastructure & Services	Land Use
Catastrophic	Long term loss of community assets and infrastructure. Irreversible loss of private property	Regional Infrastructure (e.g. Pacific Highway, Airport, Railway, Harbour, Hospitals, STPs), major regional economic industries
Major	Major asset damage, severe impact on community services and assets. Long term loss of private property.	Private property (residential) High value public assets (e.g. beach amenity where migration not possible due to backing development, schools, churches, heritage sites, etc)
Moderate	Considerable impact upon access to services, infrastructure (roads, hospitals, airports, STP, schools, beach access). Major long term impact upon private property.	Commercial business land, intensive / productive agriculture lands
Minor	Minor short term impacts (mainly reversible) on community services. Minor long-term impacts to private property.	Rural land (low productivity) High value vegetation outside of National Parks and State Forest, with limited geographic extent (e.g. SEPP14, SEPP26, EECs)
Insignificant	Little to no impact on communities and their access to services. Minor impact to private property.	National Park, State Forest, low value open space / public land

Level of Risk: Likelihood X Consequence

As given in ISO 31000:2009, the level of risk is expressed in terms of the product of consequence and likelihood. A risk matrix should be defined to describe the combination of likelihood and consequence to give a level of risk, for example, extreme, high, medium and low, as used in the example from Coffs Harbour, Table 4.

Where likelihood and consequence are mapped, a risk map describing the level of risk to areas in the coastal zone can be developed, such as for Coffs Harbour in Figure 4. In this example, the mapping enables identification of the level of risk to critical built assets from erosion and recession by 2100. The mapping can also highlight the level of risk from erosion and recession on community assets such as beach amenity on highly developed beachfronts, or level of risk of coastal erosion to significant ecology outside of protected parks and forest.

Table 4 Example Risk Matrix defining Level of Risk from Likelihood x Consequence

		CONSEQUENCE				
		Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
LIKELIHOOD	Almost Certain 5	low	medium	high	extreme	extreme
	Likely 4	low	medium	high	extreme	extreme
	Possible 3	low	medium	high	high	extreme
	Unlikely 2	low	medium	medium	high	extreme
	Rare 1	low	low	medium	medium	high

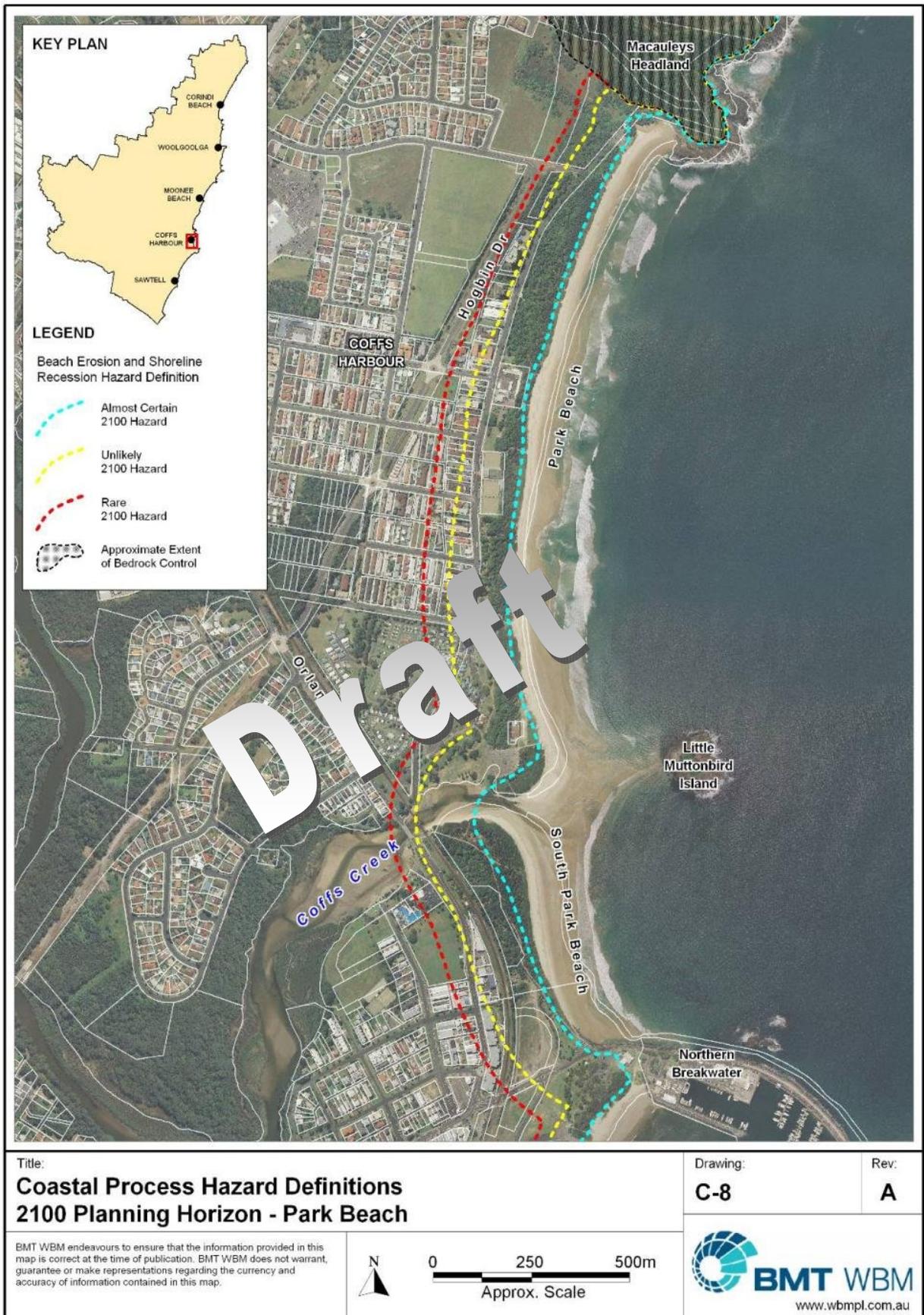


Figure 2 Draft 2100 Hazard Likelihoods Park Beach, Coffs Harbour

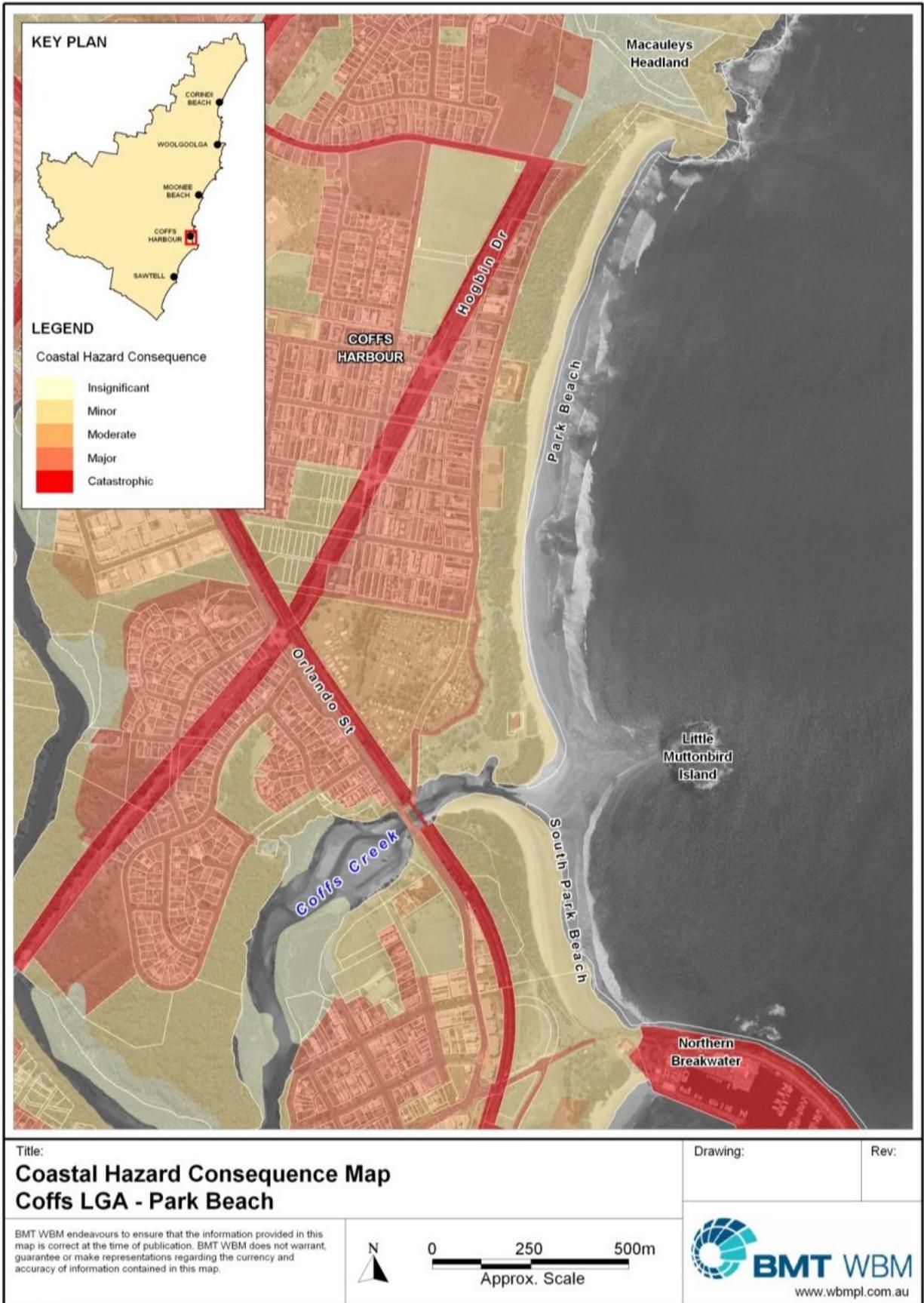


Figure 3 Example Consequence Map, Coffs Harbour

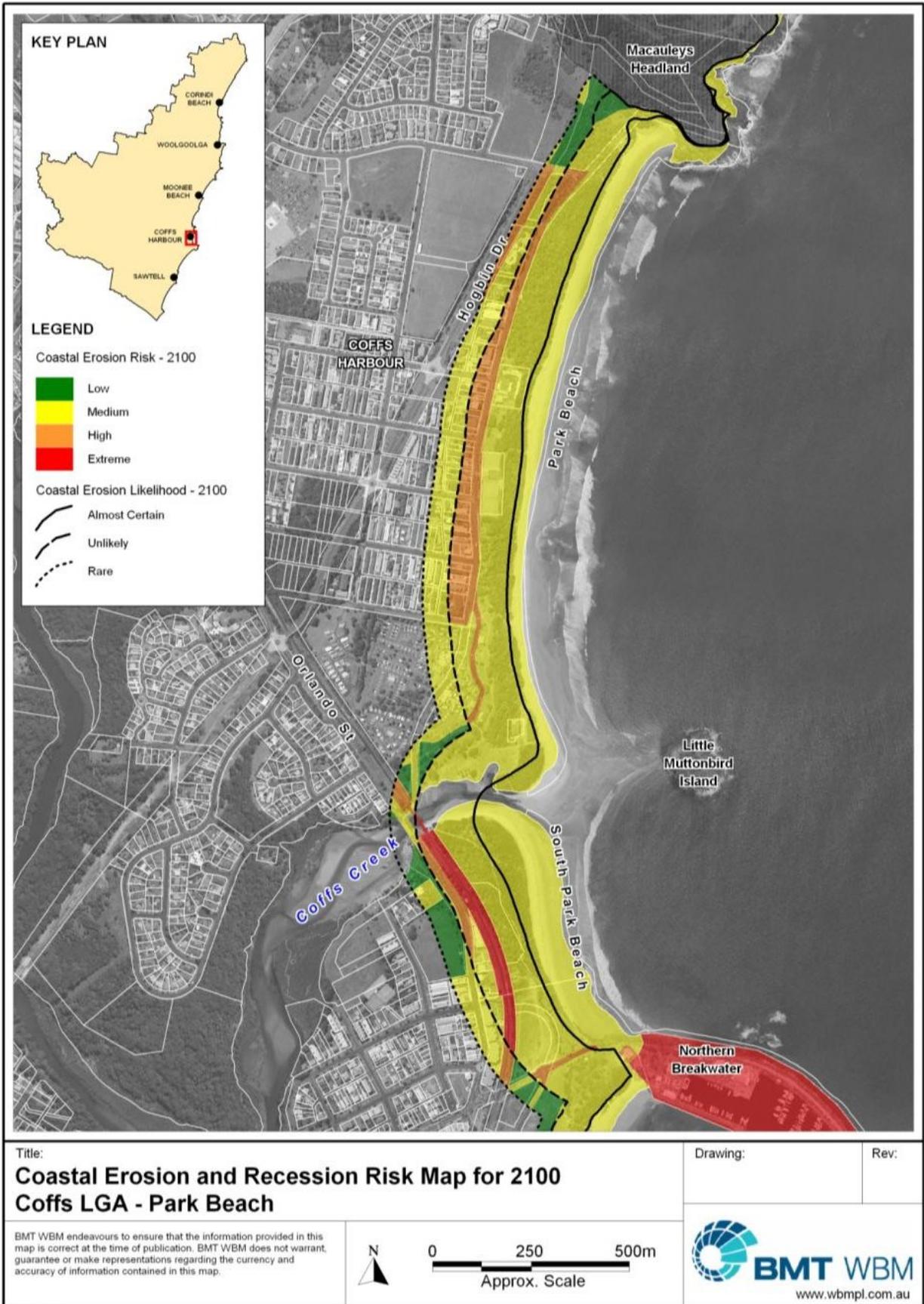


Figure 4 Example Risk Map (Likelihood x Consequence), Coffs Harbour

Evaluate the Risks

Risk evaluation, as defined in ISO 31000: 2009 involves comparing the results of the risk analysis with risk criteria, to determine whether the level of risk is acceptable, tolerable or intolerable, with intolerable risks requiring treatment as a priority. Given finite resources, it will not be possible to treat every risk, and indeed, there is a point where the cost of implementing a treatment far outweighs the benefit (or risk reduction) gained.

Prior to investigating new management measures, the existing controls or measures in place that may reduce the level of risk are evaluated. The combination of likelihood and consequence in the previous step presents the 'unmitigated' risk, and there may already be controls in place to manage such risks. For example, while the 'unmitigated' risk of coastal inundation may be high, when existing floodplain development controls are applied, the risk level may be lowered to tolerable.

Once existing management measures have been included in the assessment, the risk evaluation process identifies the priority risks requiring treatment. Management effort shall be aimed towards the higher levels of risk (e.g. extreme and high) that would be deemed intolerable. The monitoring and review process enables tracking of all risks, to ensure they remain within an acceptable range.

Treating the Risks: Preparing Coastal Management Actions

The process of developing management options as part of coastal zone management plans aims to avoid, reduce or eliminate intolerable risks. Management options can be designed to reduce the likelihood of the risks (e.g. planning setbacks to reduce the likelihood of shoreline recession impacts) or the consequence of the risk (e.g. emergency management to reduce the consequence of shoreline recession) or both. Further cost benefit analysis is then used to determine which of the risk treatments will provide the greatest benefit (relative to cost) in treating the highest priority risks. These would be selected for implementation within a coastal zone management plan.

The traditional coastal management options of 'retreat', 'protect' or 'accommodate' remain largely valid. However, there has (and will continue to be) innovation in what such options involve, and where and when they are implemented.

Unlike flooding or coastal inundation risks which may occur at any time, recession and erosion tends to occur over years with preceding events giving warning of the imminent threat. Such time warnings can be used to advantage in developing and implementing management options, particularly where the action may be costly or difficult for community to accept or implement.

Fisk and Kay (2010) provide a method for setting triggers along a time continuum for climate change adaptation actions. The method was developed as part of the climate change adaptation planning process, in recognition that at some point in the future, difficult decisions with more significant tradeoffs will need to be made. Fisk and Kay (2010) identify the need to examine three stages for each identified risk as part of the risk assessment process, being:

- the current condition of the parameter being examined;
- the undesirable end state or result that needs to be avoided; and
- identification of one or more trigger points along a time continuum that are flags to managers where more aggressive or decisive actions must be implemented in order to avoid the undesirable end state.

The timing of erosion and recession impacts can also be used to advantage by planners in generating funds to implement more costly actions that have high community benefit. Acquisition theoretically provides a 'win-win' scenario in which landholders are adequately compensated for at-risk coastal land and the community regains public reserves to ensure continuation of the beach amenity. In practice, acquisition has been difficult to implement. Unlike flood-prone land, coastal land is typically the most expensive real estate in Australia, and in most cases, councils and state government haven't the funds to acquire such properties.

One model for the acquisition of land by Council that can be investigated for its financial viability is as follows. Given the timeframes for most private property at risk from recession is greater than 20-30 years, councils may be able to buy the property under typical mortgage-type loan arrangements (underwritten by Government, financial institution or other investment mechanism), then rent back the property at market rates, providing a mechanism for council to meet loan repayments. At such time in the future when the recession impact manifests, the rental property can be demolished and returned to public reserve. Until such time, however, the financial gain from rental of prime waterfront property can be realised by council and community. The concept requires further economic analysis, however, it is similar to processes for pre-purchasing land for future proposed highway easements.

Across any one LGA, a coastal zone management plan will likely involve varied options, taking into account both the spatial nature of the identified risks, the level of risk and existing resources.

Implementation, Monitoring and Review

The coastal zone management plan details how the recommended management options (risk treatments) shall be implemented (costs, timeframes etc) and funded. Monitoring and review has always been a component of the coastal management process, on a 10 year basis. Within a risk assessment framework, risk levels are monitored for change, be it an increase or decrease in the level of risk over time, with management actions modified in response to such changes. This should occur for example as and when sea level rise projections are updated. Monitoring and review also provides for the outcome of management responses to be tracked against performance indicators.

Setting triggers for management action in the fashion outlined above, is a further tool to assist in the monitoring and review process. As triggers are approached, there is a clear signal to management agencies that action will need to be taken. Alternatively as part of the review of plan, if the risk profile has not changed, it may be wise to continue to delay action until such time as the likelihood and consequences of the risk can be better defined.

Conclusions

The standard risk management process can be readily adapted to the coastal zone management framework in NSW. The risk assessment process enables objectives, scope and context of the plan to be clearly defined from the outset of the planning process. Ascribing likelihood to hazards estimates overcomes many of the issues of the past coastal management framework, by providing transparency about the uncertainty in methods and data limitations involved in estimating hazards. Further, coastal planners and community become better informed regarding the uncertainty of

natural coastal processes. Defining consequence based upon land values (community, financial and so on) guides management effort towards those regions most at risk, or of greatest value to the community. Accepting that not all risks can (or need) to be treated, the risk assessment guides coastal management resources towards the highest priority risks.

Finally, as part of the approach to managing coastal hazards, innovative ideas are needed to minimise coastal risks, meet the demands of population growth and pressures in the coastal zone within the existing legislative framework and with relatively limited financial resources. A trigger based approach to management may assist in resources only being used when an impact becomes imminent, providing more time for community to prepare for impacts, should the need arise. Likewise, there may be viable 'win-win' acquisition options that enable councils to acquire coastal private property using the financial benefits from such property that arises over the likely timeframe of the recession and erosion impacts.

References

Cowell, P.J., Thom, B.G., Jones, R.A., Everts, C.H., and Simanovic, D., (2006). Management of Uncertainty in Predicting Climate-Change Impacts on Beaches, *Journal of Coastal Research*, **22**, 232-245.

DECCW (2010). *Draft Guidelines for preparing Coastal Zone Management Plans*, NSW Department of Environment, Climate Change and Water, August 2010.

DP (2010). *NSW Coastal Planning Guideline: Adapting to Sea Level Rise*, NSW Department of Planning, August 2010.

Fisk, G., and Kay, R, (2010). Dealing with Uncertainty in Climate Change Adaptation Planning and Developing Triggers for Future Action, *Proceedings Practical Responses to Climate Change National Conference*, 29 Sept – 1 Oct, 2010, Melbourne.

NSW Government (1990), *Coastline Management Manual*, September 1990

Standards Australia (2009). *AS/NZS ISO 31000:2009 Risk Management – Principles and guidelines*.

Standards Australia (2004). *Risk Management Guidelines Companion to AS/NZS 4360:2004* (HB 436:2004).